The University of Jordan
School of Engineering

Degree, Department	Course Name	Course Number	Semester
Master, Mechanical Engineering	**Numerical Analysis and Optimization**	**0904702**	Spring 2024-2025

Catalog Description

Accuracy and stability of ODE solutions: One step-methods (Heun's Method, Predictor-Corrector) Adaptive step size control. Boundary and Eigen value problem. Conversion of boundary value to initial PDE solutions: Elliptic, Parabolic and Hyperbolic equations value problem. Accuracy and stability of with applications. Finite Element Method: 1-D and multidimensional unconstrained problems. Constrained optimization. Integration equations: Simpson's integration and Newton-Cotes open and closed integration.

Instructors

Name	E-mail	Sec	Office Hours	Lecture Time
Prof. Ibrahim Abu-Alshaikh		1		

Textbooks

Author(s), Title, Publisher, Year, Edition	1. Numerical Methods for Engineers, S. C. Chapra, R. P. Canale, McGraw Hill , 2021, 8th- edition, (SI units) 2. Numerical Methods for Differential Equations with Python, John S Butler, 2023

References

References	1. John Matheews & Kutis Fink "Numerical Methods Using MATLAB". 2. Richard L. Burden & J. Douglas Faies Numerical Analysis, 9th Edition 2010. 3. Hoffman J.D., "Numerical Methods for Engineers and Scientists", McGraw Hill, 1993. 4. Fausett L.V., "Applied Numerical Analysis Using MATLAB", Prentice Hall, 1999. 5. Atkinson K.E., "An Introduction to Numerical Analysis", John Wiley, 2nd Edition, 1997. 6. Daryl L. Logan "A First Course in the FEM" (2017), 6th Edition
Journals	
Team link with course materials & Lectures	

Prerequisites

Prerequisites by topic	Calculus (Differentiation, Integration), Linear Algebra, Differential Equations: ordinary and partial, Computer Programming for Engineers
Prerequisites by course	
Co-requisites by course	-
Prerequisite for	Finite Element Method 0904706

Topics Covered

Week	Topics	Textbook	Program Outcomes
1	Introduction to Numerical Methods, Problem Solving, Computer representation of numbers and Approximations and error definitions.	1	S1
2	Tylor's and Finite difference formulas	1	S2
3	Integration equations: Simpson's integration and Newton-Cotes open and closed integration. Gauss quadrature derivation and application to single and double integrals.	2	S1
4	Solution of system of linear Algebraic equations with applications.	2	S2
5	Solution of system nonlinear algebraic equations with applications in nonlinear beam deflection and Lagrange Multipliers	1	S3
6-7	Accuracy and stability of ODE solutions: One step-methods (Heun's Method, Predictor-Corrector) Adaptive step size control. Finite difference and Runge-Kutta method, Boundary and eigenvalue problem. Conversion of boundary value to initial value problem.	1	S3
8-12	Numerical Solutions of Partial Differential Equations: Elliptic, Hyperbolic and Parabolic PDEs.	1	S3
13	Finite Element Method: 1-D and multidimensional unconstrained problems	1	K1
14	Hybrid Methods and numerical methods in Artificial Intelligence (AI)	1	K2
15	Project Presentation	1	C3

Mapping of Course Outcomes to Program Outcomes

Program Outcomes	Course Outcomes
S1	1. Learn a variety of numerical methods that are useful for advanced engineering calculations.
S2	2. Calculate error, determine error propagation and how to control numerical errors.
S3	3. Appreciate the concepts of "condition", "accuracy", "stability", and "convergence"
S3	4. Solve PDE (Partial differential equations): Elliptic, Hyperbolic and Parabolic equations
K1	5. Use computer languages Python/Maple/MATLAB to solve Engineering problems by FEM
K2	6. Apply FEM for problems result in solving systems of linear and nonlinear algebraic equations: by direct or iterative methods.
S3	7. Solve ODE (ordinary differential equations) using numerical methods and compare with available analytical solution of some problems

Evaluation

Assessment Tools	Expected Due Date	Weight
First Midterm Exam		20 %
Second Midterm Exam		20 %
Homework Assignments + Project		20 %
Final Exam		40 %

Relationship to JNFQ Outcomes												
POs	**K1**	**K2**	**K3**	**S1**	**S2**	**S3**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
Availability	**X**	**X**		**X**	**X**	**X**			**X**			

JNFQ Outcomes	
K1	Specialized state-of-the-art knowledge in the field of the study.
K2	Ability to think critically about the issues of knowledge in the field of learning and at the interface between different fields.
K3	Sufficient knowledge of innovation strategies.
S1	Demonstrate the ability to apply specialized skills to solve problems required in scientific research.
S2	Ability to create new skills, tools and procedures at a high level including new and emerging technological skills.
S3	Ability to integrate knowledge from different areas of learning.
C1	Dealing with complexity of scientific problems, managing them, and taking the initiative to solve them. Formulating judgements and transferring good practices.
C2	Managing ambiguous study contexts that require a new strategic approach.
C3	Self-evaluation and responsibility for self- learning.
C4	Taking responsibility for the team work.
C5	Contributing to the vocational knowledge.
C6	Ability to review the team performance

Prepared by: Prof. Ibrahim Abu-Alshaikh, March, 2025